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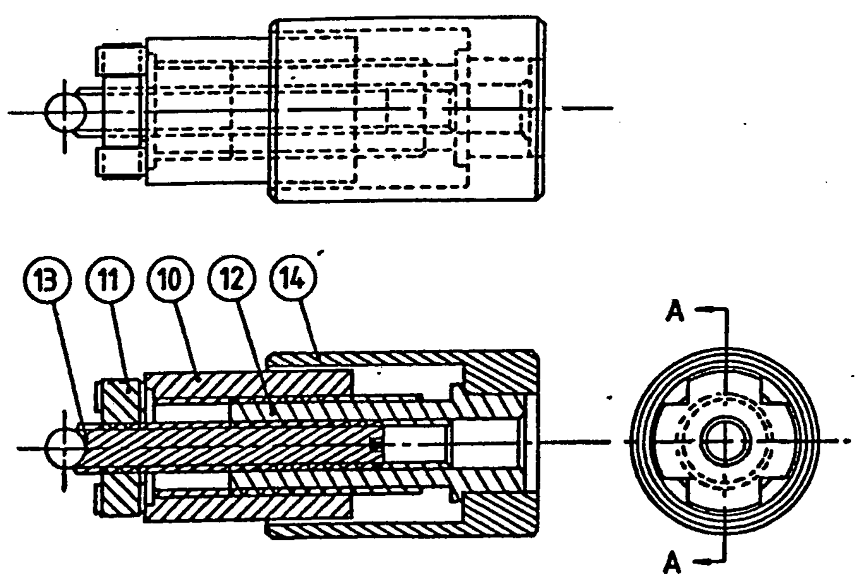
GB 0261414

(58) Field of search
F2Q
Selected US specifications from IPC sub-class F16H

(54) Differential screw and nut mechanism

(57) A differential screw and nut mechanism for rotatably adjusting a mirror through a small angle comprises a sleeve 12 having internal and external threads of different pitch, a screw actuator 13 engageably received within the sleeve 12, and a non rotatable nut member 10 surrounding the sleeve 12. A friction disc 11 restricts rotation of the screw actuator 13 whilst allowing axial movement thereof. In use rotation of the sleeve 12 *via* a member 14 produces linear movement of the actuator 13 equivalent to the difference in thread pitch between the internal and external threads on the sleeve.



Sectional View on A-A

Fig. 8

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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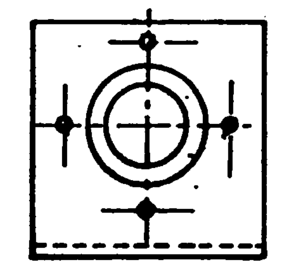

Fig. 1

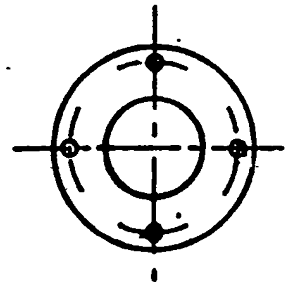

Fig. 2

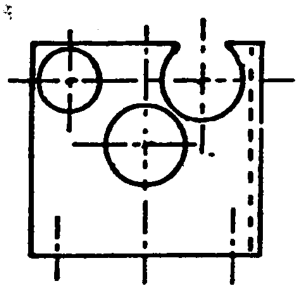

Fig. 3

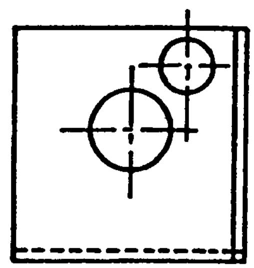

Fig. 4

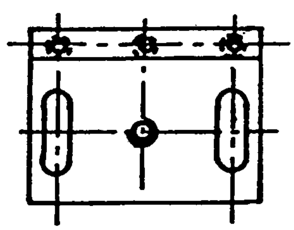

Fig. 5

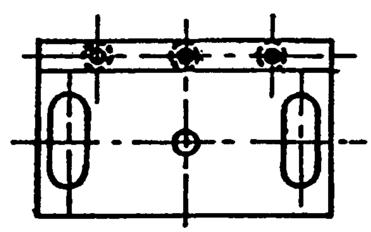

Fig. 6

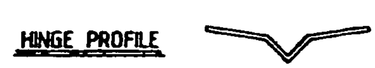

Fig. 7

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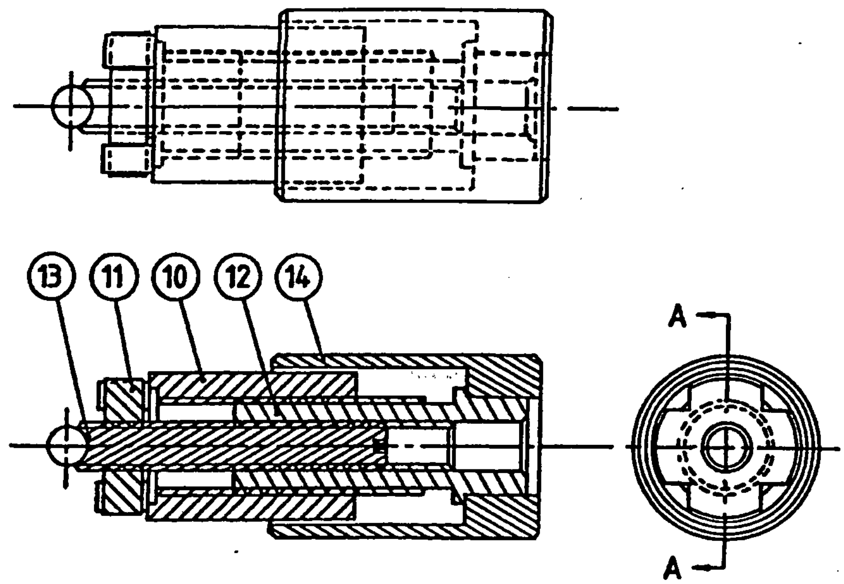

Sectional View on A-A

Fig. 8

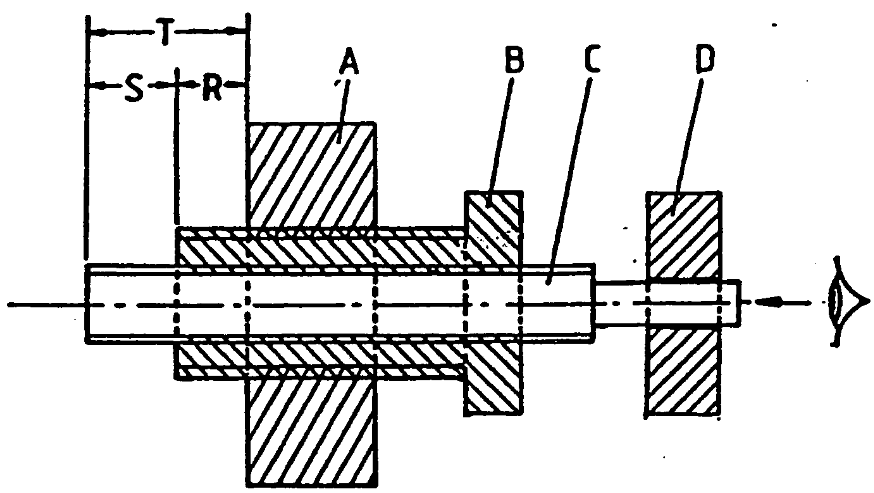

Fig. 9

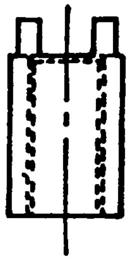

Fig. 10

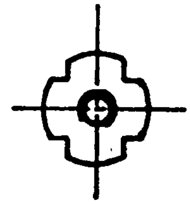

Fig. 11

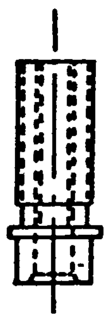

Fig. 12

Fig. 13

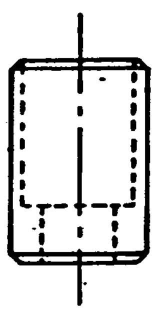

Fig. 14

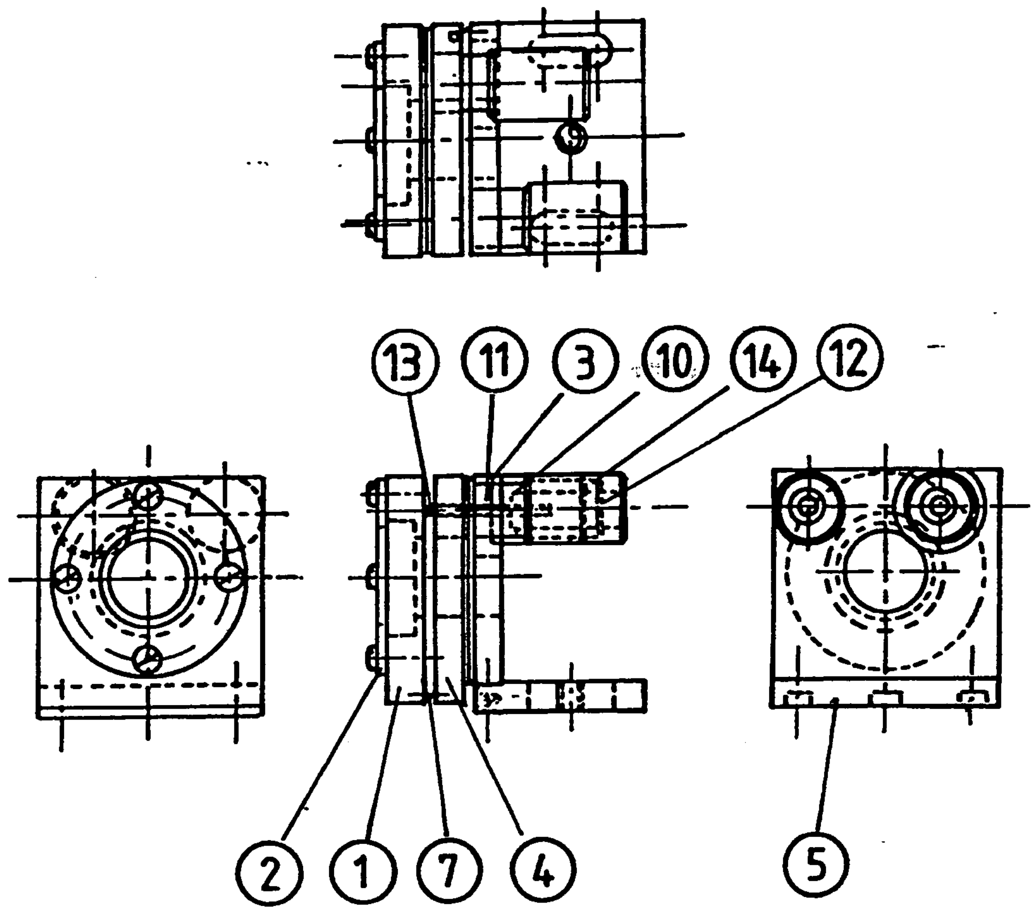

Fig. 15

ADJUSTABLE MIRROR MOUNT

The State of the Art

A wide variety of systems use light in the visible range, and many employ lasers as a light source. Inherent in these systems lies a requirement to deflect and align the light beam. A number of devices are commercially available. These range from the very basic, which are relatively inexpensive, to those which are precise devices, made to exacting limits, and are priced accordingly.

General Requirements

The general requirements of an adjustable mirror mount are as follows. It must support a mirror rigidly and without distortion. It must, by adjustment, rotate the mirror through a small angle, both plus and minus. These movements are essential on both the vertical and the horizontal axes, independently one from the other. The movement should be stable when set and wobble free whilst being adjusted.

Basic Designs

Basic designs usually rely upon a vertical fixed plate, in front of which an adjustable plate is mounted. The mirror is mounted on the face of the adjustable plate. A space which exists between the two plates, is maintained by a ball and two screws. A spring is used to pull the two plates together. The ball is located in mating conical depressions in the plates, near one corner. The two screws are positioned, one below and the the other across from the ball, in other corners of the plates. The spring is located roughly in the centre of this layout, thereby applying similar pressure to the three points of contact. Translation of the refected light beam is

achieved by turning the screws. These are invariably of fine pitch and typically 0.5mm. Unfortunately, dust and dirt which collects on the unshielded threads, may be carried into the working clearances. Undue wear could take place or the threads may become very stiff or even seize if ignored. Undesired movement of the mirror often occurs when adjusting this type of device, making precise setting rather tedious.

Middle Range Designs

These frequently rely upon two gimbals, mounted one inside the other, and pivoted at 90° with respect to one another. The drive mechanism is invariably a micrometer head for each movement and contact maintained by springs. The micrometer thread pitch is usually 0.5mm. Given a similar leverage length to the above basic design, a comparable movement rate will be experienced. The gimbal pivot is central with the mirror, whereas the pivot ball on the basic design is in a corner of the plate. To obtain similar leverage length therefore requires the gimbal designs to be physically larger. Making much larger units is not always convenient. Tapered wedges are sometimes used to increase the ratio, but these are added complications. A typical leverage length of 30mm combined with a thread pitch of 0.5mm, produces an angular displacement of 1 in 60 or 57.3 minutes of arc, per turn of the drive screw.

Precise Designs

One method of producing a much finer movement, is to replace the standard micrometer head on the above design, with differential micrometer heads. The main advantage of this change, is in respect of the effective thread pitch, which is typically 0.05mm. This gives an angular displacement of 1 in 600 or 5.73 minutes of arc at 30mm

leverage length. The cost of the two differential micrometers makes the choice of this unit very selective.

Desirable Design Elements

Independent horizontal beam translation.

Independent vertical beam translation.

Precise fine adjustments.

Stable wobble free motion.

$\pm 3^{o}$ range.

Direct mounting base.

Alternative mounting options.

Optional facility for various optical devices.

Design - with consideration to the above elements

To achieve independent motions, a three plate system was chosen. The Front Plate, Fig. 1, is designed to carry the mirror, which may be held using the Retainer, Fig. 2. Interspaced btween the Front Plate and the Back Plate, Fig. 3, is located the Centre Plate, Fig. 4. The Back Plate is attached to the Base Plate, Fig. 5, or the Alternative Base Plate, Fig. 6, which facilitates a stable mounting for the device in its working location. To achieve beam translation, the Front Plate must rotate about horizontal and vertical axes. Hinge strips, Fig. 7, located at the appropriate edges of the plates, allow this rotation. Vertical translation is controlled by the Drive Mechanism, mounted in the Centre Plate, and pushing the Front Plate at the opposite edge to its Hinge. Similarly, horizontal translation is controlled by the Drive Mechanism, mounted in the Back Plate, and pushing the Centre Plate.

An uninterrupted aperture, which extends through the Front, Centre and Back Plates, affords flexibility of optical system usage. The Hinges, which are located between the Front and Centre Plates, and between the Centre and Back Plates, have been designed to perform several functions simultaneously. Firstly, they must maintain a non-twisting relationship between the mating plates. Secondly, they need to allow a swinging motion between the mating plates. The third function is to maintain positive contact between the relevant Drive Mechanism and Plate.

The Hinges are manufactured from Copper Berylium shim strips, which when formed to their profile as shown, are heat treated to introduce a spring like nature in the material.

Slits, machined in the Plates, provide mounting locations for the Hinges, using a structural adhesive on assembly. The Hinge profile affords a preset spring load between mating plates.

DRIVE MECHANISM

Probably the most important part of the device, the design, Fig. 8, which is detailed following the screw theory, capitalises both on the benefits of a differential screw system, and also on its simplicity of construction.

Differential Screw Theory

Consider a simple screw and nut arrangement, where the nut is solidly fixed and prevented from any movement. When the screw is rotated one turn, the screw will move by an amount equal to the pitch of the thread. Consider now a simple screw and nut, where the screw is prevented from rotating, and the nut from longitudinal movement. If the nut is rotated by one turn in a clockwise direction, then the screw will move towards the operator, looking along the axis of the thread, by an amount equal to the pitch of the thread. It can be seen from the drawing, Fig. 9, that the two previously described screw and nut arrangements are effectively combined. ´A´ represents a solidly fixed nut, and ´B´ a screw which fits through it. Screw ´B´ has a second thread. This is machined down through its axis to accept thread ´C´. A device labelled ´D´ restricts thread ´C´ to longitudinal movement only, i.e. prevents its rotation.

Let us assume that the pitch of thread ´A´ is 1.1mm and the pitch of thread ´C´ is 1.0mm. Both threads are right hand and viewed from the direction as shown. The one complete clockwise turn of ´B´ will result in the following changes in dimensions R, S, and T.

R will increase by 1.1mm, by virtue of the fact that it moves forward through its nut ´A´.

S will decrease by 1.0mm, by virtue of the fact that its effective nut, screw ´B´, moves forward on screw ´C´, which cannot revolve.

In other words R will become R+1.1mm.

S will become S-1.0mm.

therefore T, which equals R+S will become

$$R=[R+1.1]+[S-1.0]$$

$$T=R+1.1+S-1.0$$

$$T=R+S+1.1-1.0$$

$$T=R+S+0.1$$

thus T will increase by 0.1mm, whilst R will increase by 1.1mm.

Drive Mechanism Design

The Body, Fig. 10, is machined to close tolerances, with a set of posts protruding from one end. These posts locate the Friction Disc, Fig. 11, and prevent its rotation whilst still allowing longitudinal motion. The Main Screw, Fig. 12, has two threads. The outer thread runs in the Body, whilst the Drive Screw, Fig. 13, runs in the inner. Fitted to the plain end of the Main Screw is the Thimble, Fig. 14. This acts both as a textured knob, with which to turn the Main Screw, and also as a cover shield to its thread. The Drive Screw is made from a socket set screw and a chrome steel ball. Undesired rotation of the Drive Screw is prevented by manufacturing the Friction Disc, with an undersize thread, from a plastic material.

These five components, when assembled, produce the Drive Mechanism, which is attached to the appropriate Plate described previously. Threads have been chosen such that one turn in operation will result in an effective movemnt of 0.05mm on the Drive Screw, i.e. approximately 6 minutes of arc on the Front Plate. The Drive Mechanism mounted in the Centre Plate, passes through the Back Plate with sufficient clearance to ensure an interference free operation.

Summary

The completed Adjustable Mirror Mount is shown in Fig. 15, and is capable of aligning a light beam, reflected from its mirror, to within 1mm of a target spot which is 20 metres distant. That is 1 in 20,000 or 10 seconds of arc. The beam can be translated through an angle of 7° in both the vertical and horizontal. Coarse adjustments are activated using a hexagonal wrench inserted directly in the appropriate Drive Screw. The range of the fine adjustment is 1½ minutes of arc. Both coarse and fine adjustments operate non preferentially; they may if desired, be in motion simultaneously.

With the exception of the threaded parts, the device is finished in matt black.

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CLAIMS.

1. A drive mechanism in which one threaded component part operates on at least two others simultaneously to produce differential fine movements.

2. A drive mechanism as claimed in 1 wherein means are provided to control rotation by friction whilst allowing axial translation of at least one component part.

3. A drive mechanism as claimed in 1 and 2 wherein there are means of producing non differential coarse movements.

4. A drive mechanism substantially as described herein with reference to the drawings.

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